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(54) **PWB COOLING SYSTEM WITH HEAT DISSIPATION THROUGH POSTS**

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H05K 1/02 (2006.01)
H05K 3/00 (2006.01)

(52) **U.S. Cl.**
CPC ***H05K 1/0209*** (2013.01); ***H05K 3/0061*** (2013.01); *H05K 1/0204* (2013.01); *H05K 2201/10416* (2013.01); *H05K 2201/10553* (2013.01)

(58) **Field of Classification Search**
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USPC 174/252, 260
See application file for complete search history.

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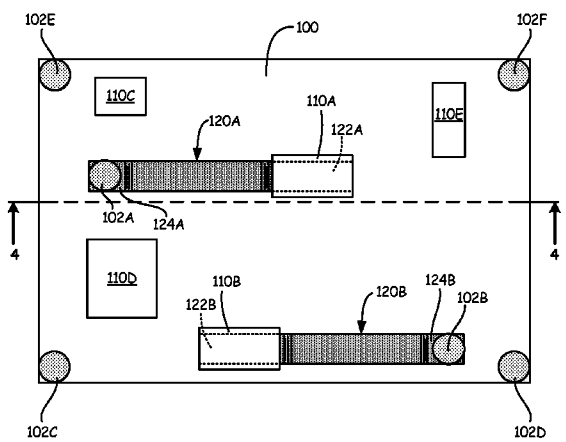
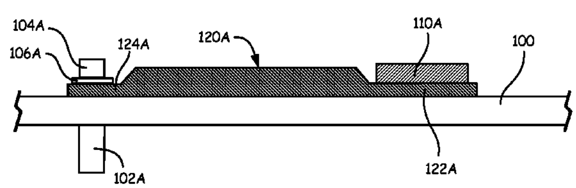
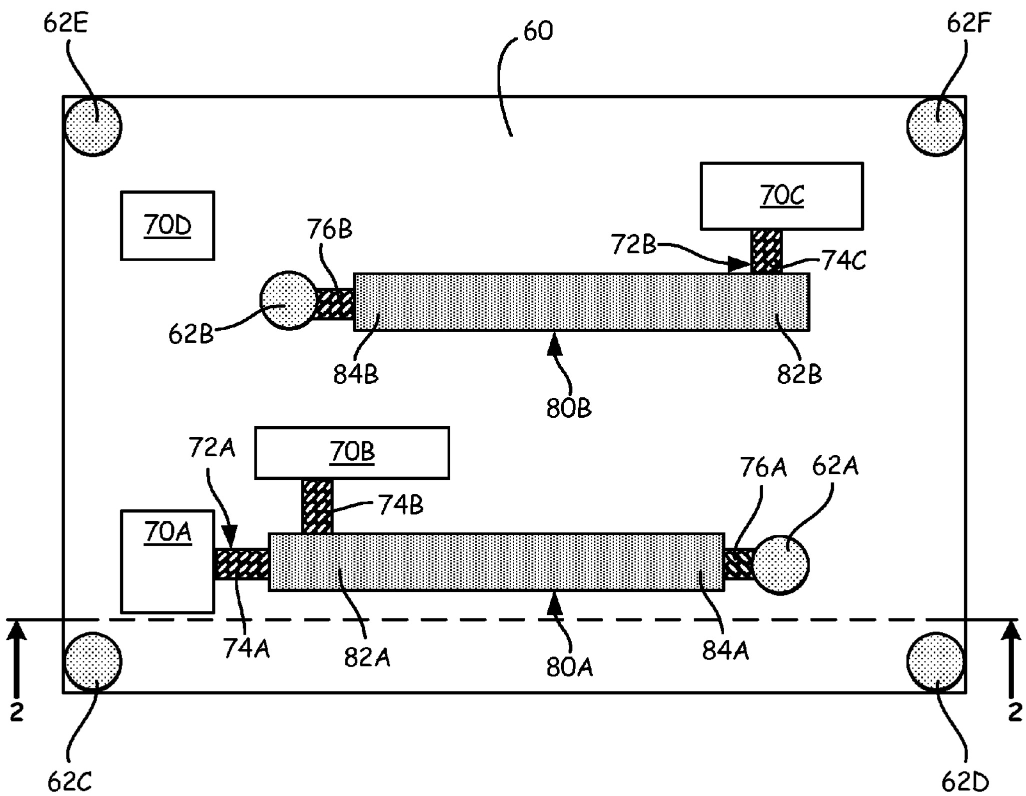
(57) **ABSTRACT**

An apparatus includes a printed wiring board, a post that supports the printed wiring board, and a heat pipe on the printed wiring board with a first end positioned near an electronic component attached to the printed wiring board and a second end positioned near the post.

20 Claims, 4 Drawing Sheets






62E
60
62F
70C
70D
76B
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74C
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80B
82B
72A
70B
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62A
74B
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FIG. 1

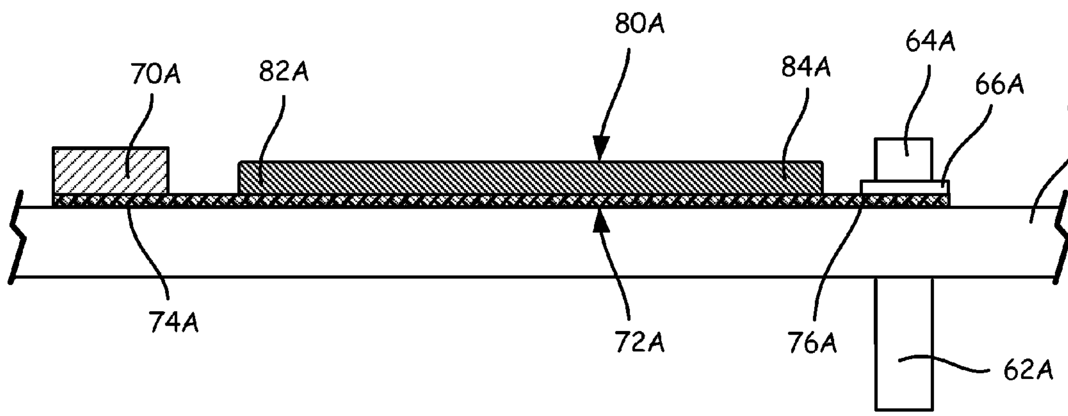
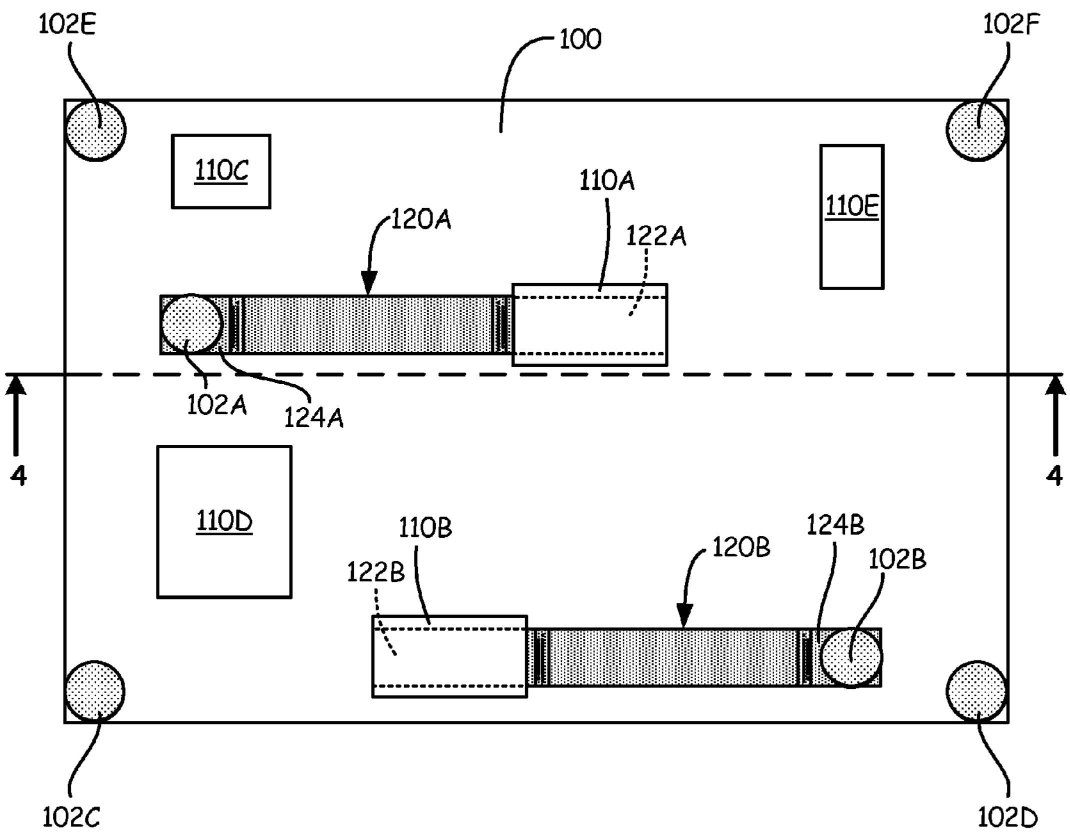


FIG. 2



102E
100
102F
110C
110A
120A
122A
110E
102A
124A
4
4
110D
110B
124B
120B
102B
122B
102C
102D

FIG. 3

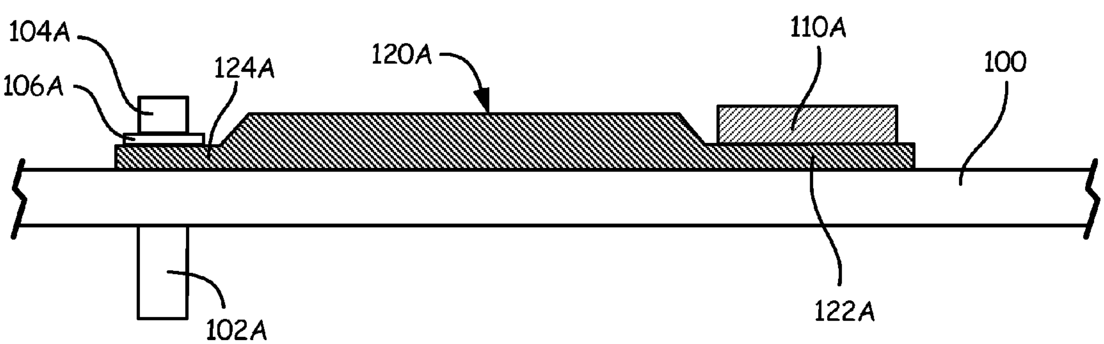


FIG. 4

PWB COOLING SYSTEM WITH HEAT DISSIPATION THROUGH POSTS

BACKGROUND

The present invention relates to a cooling apparatus for printed wiring boards.

Thermal management of aircraft mounted electronic components is becoming increasingly more challenging with the higher density of more powerful, but smaller electronic components. Currently, heat pipe embedded heat sinks have been used to move heat from a hot electronic component on a printed wiring board to cooler locations. Heat pipe embedded heat sinks have an inherent loss of efficiency in that the heat has to move from the electronic component, through the printed wiring board, to the heat sink, and then to a cooler location. This design is also severely limited in applications where there are electronic components on two sides of a printed wiring board. Further, the heat sink adds excessive weight and cost to the overall electronic assembly.

Due to space limitations on aircraft, printed wiring boards are typically stacked on top of one other and separated with posts. These posts are separate pieces that are attached to a printed wiring board and/or heat sink with screws. The posts support the printed wiring boards and create space between the printed wiring boards so that air can flow around the printed wiring boards. The posts can also be used to suspend a printed wiring board in a chassis that is mounted on an aircraft.

SUMMARY

An apparatus includes a printed wiring board, a post that supports the printed wiring board, and a heat pipe on the printed wiring board with a first end positioned near an electronic component attached to the printed wiring board and a second end positioned near the post.

An apparatus for cooling an electronic component on a printed wiring board includes a printed wiring board, an electronic component attached to the printed wiring board, a plurality of posts attached to the printed wiring board, and a heat pipe attached to the printed wiring board with a first end near the electronic component and a second end near one of the plurality of posts.

A method for cooling an electronic component on a printed wiring board includes absorbing heat into a first end of a heat pipe that is positioned on a printed wiring board from an electronic component on the printed wiring board, transferring the heat through the heat pipe, and releasing the heat at a second end of the heat pipe into a post supporting the printed wiring board.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a top plan view of a first embodiment of a printed wiring board with a heat pipe.

FIG. **2** is a cross-sectional view of the first embodiment of the printed wiring board, taken along line **2-2** of FIG. **1**.

FIG. **3** is a top plan view of a second embodiment of a printed wiring board with a heat pipe.

FIG. **4** is a cross-sectional view of the second embodiment of the printed wiring board taken along line **4-4** of FIG. **3**.

DETAILED DESCRIPTION

In general, the present invention relates to transferring heat from an electronic component to a post using a heat pipe. With advancements in technology, more powerful electronic components are being used in aircraft applications. These electronic components tend to be higher heat generating electronic components, so more effective heat dissipating arrangements are needed to cool these components. The present application discloses multiple arrangements where heat can be transferred from a high heat generating electronic component on a printed wiring board through a heat pipe to a post that supports the printed wiring board. The post can then dispel the heat into an ambient, thus cooling the overall electronic assembly.

FIG. **1** is a top plan view of a first embodiment of printed wiring board **60** with heat pipes **80**. Printed wiring board **60** includes posts **62** (including post **62**A, post **62**B, post **62**C, post **62**D, post **62**E, and post **62**F), electronic components **70** (including electronic component **70**A, electronic component **70**B, electronic component **70**C, and electronic component **70**D), copper traces **72** (including copper trace **72**A and copper trace **72**B), and heat pipes **80** (including heat pipe **80**A and heat pipe **80**B). Each copper trace **72** has at least one electronic component connecting end **74** and post connecting end **76**. Copper trace **72**A has electronic component connecting end **74**A, electronic component connecting end **74**B, and post connecting end **76**A. Copper trace **72**B has electronic component connecting end **74**C and post connecting end **76**B. Each heat pipe **80** has first end **82** and second end **84**. Heat pipe **80**A has first end **82**A and second end **84**A. Heat pipe **80**B has first end **82**B and second end **84**B.

Printed wiring board **60** can be any board that is capable of holding electronic components **70** on a top side of printed wiring board **60**. Printed wiring board **60** can be constructed with any suitable size and weight. In the embodiment shown in FIG. **1**, four electronic components **70**A-**70**D are positioned on printed wiring board **60**. In alternate embodiments, the number and position of electronic components **70** on printed wiring board **60** can vary. Posts **62** are attached to a bottom side of printed wiring board **60** with fasteners extending up through printed wiring board **60** to the top side of printed wiring board **60**. In the embodiment shown in FIG. **1**, six posts **62**A-**62**F are positioned on printed wiring board **60**. In alternate embodiments, the number and position of posts **62** on printed wiring board **60** can vary.

Heat pipes **80** are also positioned on the top side of printed wiring board **60**. Heat pipes **80** are soldered to printed wiring board **60** along copper traces **72** in the embodiment shown, but can be connected to printed wiring board **60** with any suitable means in alternate embodiments, including bonding, welding or pressing. Heat pipes **80** include first ends **82** positioned near electronic components **70** and second ends **84** positioned near posts **62**. In the embodiment shown in FIG. **1**, two heat pipes **80**A and **80**B are positioned on printed wiring board **60**. First end **82**A of heat pipe **80**A is positioned near electronic component **70**A and electronic component **70**B. Second end **84**A of heat pipe **80**A is positioned near post **62**A. First end **82**B of heat pipe **80**B is positioned near electronic component **70**C. Second end **84**B of heat pipe **80**B is positioned near post **62**B. In alternate embodiments, the number and position of heat pipes **80** can vary. Further, the number of electronic components **70** that are positioned near first ends **82** of heat pipes **80** can vary. In the embodiment shown in FIG. **1**, one second end **84** of one heat pipe **80** ends at one post **62**. In alternate embodiments, the number of second ends **84** of heat pipes **80** that end at one post **62** can vary.

Heat pipe **80** includes a hollow housing. The housing can contain a working fluid that is capable of two-phase heat transfer and a wick material on interior surfaces of the housing to wick the working fluid from second ends **84** of heat pipes **80** to first ends **82** of heat pipes **80**. Heat from electronic components **70** will enter heat pipes **80** at first end **82**, causing the working fluid to vaporize. The vaporized working fluid can then be transferred through heat pipe **80**. The vaporized working fluid can release the heat into post **62** at second end **84**, causing the working fluid to condense. The wick material can then transfer the condensed working fluid back to first end **82**. Heat pipes **80** can be constructed out of any suitable materials, including any suitable housing material, any suitable working fluid, and any suitable wick material. Heat pipes **80** can be shaped and sized to fit in any arrangement on printed wiring board **60**. This includes flattening heat pipes **80** to fit on printed wiring board **60** if desired.

Copper traces **72** are positioned on the top side of printed wiring board **60** to run between electronic components **70** and posts **62**. Copper traces **72** each include at least one electronic component connecting end **74** and post connecting end **76**. Electronic component connecting ends **74** of copper traces **72** are positioned between electronic components **70** and heat pipes **80** to direct the heat generated by electronic components **70** to first ends **82** of heat pipes **80**. Post connecting ends **76** are positioned between heat pipes **80** and posts **62** to direct the heat from second ends **84** of heat pipes **80** into posts **62**.

The size, shape, and placement of copper traces **72** can vary. In the embodiment shown in FIG. **1**, copper trace **72**A has electronic component connecting end **74**A positioned between electronic component **70**A and first end **82**A of heat pipe **80**A to transfer heat from electronic component **70**A to heat pipe **80**A. Copper trace **72**A also has electronic component connecting end **74**B positioned between electronic component **70**B and first end **82**A of heat pipe **80**A to transfer heat from electronic component **70**B to heat pipe **80**A. Copper trace **72**A also has post connecting end **76**A positioned between second end **84**A of heat pipe **80**A and post **62**A to transfer heat from heat pipe **80**A to post **62**A. Copper trace **72**B has electronic component connecting end **74**C positioned between electronic component **70**C and first end **82**B of heat pipe **80**B to transfer heat from electronic component **70**C to heat pipe **80**B. Copper trace **72**B also has post connecting end **76**B positioned between second end **84**B of heat pipe **80**B and post **62**B to transfer heat from heat pipe **80**B to post **62**B. Copper traces **72** can be added to printed wiring board **60** when printed wiring board **60** is manufactured using any suitable manufacturing process.

Placing heat pipes **80** directly on printed wiring board **60** is advantageous, as it more effectively transfers heat from electronic components **70** to heat pipes **80**. It is further advantageous, as a heat sink does not have to be used in combination with the printed wiring board **60** to effectively transfer heat from printed wiring board **60** to an ambient. Eliminating the need to use a heat sink is advantageous, as it reduces the overall weight of the printed wiring board assembly and reduces the cost of procuring and storing a heat sink and the time needed to assemble a printed wiring board assembly with a heat sink. Further, when a heat sink is used to cool printed wiring board **60** it is placed against one side of printed wiring board **60**. Printed wiring boards **60** can hold electronic components **70** on both sides, but when a heat sink is used in connection with printed wiring board **60**, the space on which electronic components **70** can be placed is severely limited. By placing heat pipe **80** directly on printed wiring board **60**, the need to use a heat sink to cool printed wiring board **60** is eliminated, which provides more space on printed wiring board **60** where electronic components **70** can be placed.

Placing heat pipes **80** between electronic components **70** and posts **62** is further advantageous, as it more effectively transfers heat from the electronic components to an ambient. Previously used models that utilize a heat sink to transfer heat from electronic components **70** to an ambient have an inherent loss of thermal efficiency between printed wiring board **60** and the heat sink. Placing heat pipes **80** on printed wiring board **60** more efficiently transfers heat from electronic components **70** to posts **62**, as there is no thermal energy lost between printed wiring board **60** and the heat sink. Further, placing heat pipe **80** directly on printed wiring board **60** allows the heat to be evened out on printed wiring board **60**.

Positioning heat pipes **80** between electronic components **70** and posts **62** is also advantageous, as dissipating heat through posts **62** will more effectively cool printed wiring board **60**. Posts **62** can be attached to printed wiring board **60** to provide a thermal path along which heat can dissipate. Dispelling heat from posts **62** into an ambient more efficiently cools printed wiring board **60** over previously used models. Having more effective cooling allows higher heat generating and more powerful electronic components **70** to be used. This allows flexibility in the design of printed wiring board **60** and allows more effective and reliable electronic components **70** to be used.

FIG. **2** is a cross-sectional view of the first embodiment of printed wiring board **60**, taken along line **2-2** of FIG. **1**. Printed wiring board **60** includes post **62**A, fastener **64**A, washer **66**A, electronic component **70**A, copper trace **72**A, and heat pipe **80**A. Copper trace **72**A has electronic component connecting end **74**A and post connecting end **76**A. Heat pipe **80**A includes first end **82**A and second end **84**A.

Printed wiring board **60** is supported by post **62**A. Post **62**A is attached to a bottom side of printed wiring board **60** with fastener **64**A and washer **66**A. Fastener **64**A is placed through washer **66**A, printed wiring board **60**, and into post **62**A. Electronic component **70**A is positioned on a top side of printed wiring board **60**.

Heat pipe **80**A is also positioned on the top side of printed wiring board **60**. First end **82**A of heat pipe **80**A is positioned near electronic component **70**A and second end **84**A of heat pipe **80**A is positioned near post **62**A. Also positioned on the top side of printed wiring board **60** is copper trace **72**A. Copper trace **72**A runs between heat pipe **80**A and printed wiring board **60** and also between electronic component **70**A and printed wiring board **60**. Copper trace **62**A allows electronic component **70**A and heat pipe **80**A to be soldered to printed wiring board **60** in the embodiment shown, but in alternate embodiments electronic component **70**A and heat pipe **80**A can be attached to printed wiring board **60** using any suitable means.

Copper trace **72**A has electronic component connecting end **74**A and post connecting end **76**A. Electronic component connecting end **74**A of copper trace **72**A is positioned between electronic component **70**A and first end **82**A of heat pipe **80**A to transfer heat from electronic component **70**A to first end **82**A of heat pipe **80**A. Electronic component connecting end **74**A extends underneath electronic component **70**A to effectively absorb heat generated by electronic component **70**A. With this arrangement, heat pipe **80**A will absorb heat from electronic component **70**A at first end **82**A via electronic component connecting end **74**A of copper trace **72**A. The heat will then be transferred through heat pipe **80**A with phase-change heat transfer. The heat can then be released from second end **84**A of heat pipe **80**A into post **62**A via post connecting end **76**A of copper trace **72**A. Post connecting end **76**A of copper trace **72**A is positioned between second end **84**A of heat pipe **80**A and post **62**A. Post connecting end **76**A of copper trace **72**A extends underneath washer **66**A to effectively released heat from heat pipe **80**A into post **62**A. The heat can then be dissipated through post **62**A into an ambient.

Using electronic component connecting end **74**A of copper trace **72**A to transfer heat from electronic component **70**A to first end **82**A of heat pipe **80**A is advantageous, as it provides a pathway through which the heat can travel to direct the heat to first end **82**A of heat pipe **80**A. Using post connecting end **76**A of copper trace **72**A to transfer heat from second end **84**A of heat pipe **80**A to post **62**A is also advantageous, as it provides a pathway through which the heat can travel to direct the heat to post **62**A. Copper has high thermal conductive properties, thus heat will tend to transfer through copper trace **72**A versus dissipating into surrounding areas on printed wiring board **60**. This will increase the effectiveness of the overall thermal energy transfer, as heat from electronic component **70**A will transfer through copper trace **72**A into first end **82**A of heat pipe **80**A instead of other areas of printed wiring board **60**. Likewise, heat from second end **84**A of heat pipe **80**A will transfer through copper trace **72**A into post **62**A instead of other areas of printed wiring board **60**. This prevents printed wiring board **60** from getting too hot and provides a better cooling pathway for electronic component **70**A through printed wiring board **60** and post **62**A into an ambient.

Transferring heat from electronic component **70**A through heat pipe **80**A to post **62**A is advantageous, as it allows for more efficient heat transfer through printed wiring board **60** and into an ambient. Post **62**A provides a thermal pathway through which heat can be transferred from electronic component **70**A to an ambient. Using post **62**A to dispel heat from printed wiring board **60** to an ambient provides for more efficient cooling of printed wiring board **60**. Having more efficient cooling of printed wiring board **60** allows higher heat generating and more powerful electronic components **70** to be used on printed wiring board **60**. This provides greater flexibility in the design of printed wiring board **60** and allows more effective and reliable electronic components **70** to be used. These electronic components **70** tend to be smaller in size and weight than previously used electronic components, making then advantageous for use in aircraft applications. Reducing the overall weight of an aircraft is advantageous, as it allows for greater efficiency of the aircraft.

Further, attaching heat pipe **80**A directly to printed wiring board **60** is advantageous in aircraft applications, as heat pipe **80**A will be able to survive in harsh aircraft engine mount environments. This creates greater flexibility in where printed wiring board **60** can be mounted. Attaching heat pipe **80**A directly to printed wiring board **60** also reduces material procurement costs, inventory costs, and assembly costs. Heat pipes that were used in previous aircraft applications required thermal pads and other additional parts to accommodate for vibration and tolerance. Attaching heat pipe **80**A directly to printed wiring board **60** eliminates the need for additional parts, which eliminates the cost and time associated with procuring and storing these parts. It also reduces the cost and time required to assemble the overall printed wiring board assembly.

FIG. **3** is a top plan view of a second embodiment of printed wiring board **100** with heat pipes **120**. Printed wiring board **100** includes posts **102** (including post **102**A, post **102**B, post **102**C, post **102**D, post **102**E, and post **102**F), electronic components **110** (including electronic component **110**A, electronic component **110**B, electronic component **110**C, electronic component **110**D, and electronic component **110**E), and heat pipes **120** (including heat pipe **120**A and heat pipe **120**B). Each heat pipe **120** has first end **122** and second end **124**. Heat pipe **120**A has first end **122**A and second end **124**A. Heat pipe **120**B has first end **122**B and second end **124**B.

Printed wiring board **100** can be any board that is capable of holding electronic components **110** on a top side or a bottom side of printed wiring board **100**. In the embodiment shown in FIG. **3**, five electronic components **110**A-**110**E are positioned on a top side of printed wiring board **100**. In alternate embodiments, the number and position of electronic components **110** on printed wiring board **100** can vary. Posts **102** are attached to a bottom side of printed wiring board **100** with fasteners extending up through printed wiring board **100** to the top side of printed wiring board **100**. In the embodiment shown in FIG. **3**, six posts **102**A-**102**F are positioned on printed wiring board **100**. In alternate embodiments, the number and position of posts **102** on printed wiring board **100** can vary.

Heat pipes **120** are also positioned on the top side of printed wiring board **100**. Heat pipes **120** include first ends **122** and second ends **124**, each of which are flattened. The ends of heat pipes **120** are flattened so that they can be positioned to more effectively transfer heat across printed wiring board **100**. First ends **122** and second ends **124** can be flattened by clamping them while heat pipes **120** are being manufactured, or by any other suitable means that will flattened the ends of heat pipes **120**. First ends **122** of heat pipes **120** should be sized to fit underneath electronic components **110**. Second ends **124** of heat pipes **120** should be similarly sized to posts **122** and have an aperture running through them so that they can be mounted to post **122**. The aperture can be drilled into second end **124** of heat pipe **120** after heat pipe **120** is manufactured, or by any other suitable means that can create an aperture through second end **124** of heat pipe **120**.

Heat pipes **120** includes a hollow housing. The hollow housing can contain a working fluid that is capable of two-phase heat transfer and a wick material on interior surfaces of the housing to wick the working fluid from second ends **124** of heat pipes **120** to first ends **122** of heat pipes **120**. The working fluid in heat pipe **120** runs does not extend into flattened first end **122** or flattened second end **124** of heat pipe **120**, but rather runs through a center portion of heat pipe **120** that is not flattened. Heat from electronic components **110** will enter heat pipes **120** at first end **122**, causing the working fluid to vaporize. The vaporized working fluid can then be transferred through heat pipe **120**. The vaporized working fluid can release the heat into post **102** at second end **124**, causing the working fluid to condense. The wick material can then transfer the condensed working fluid back to first end **122**. Heat pipes **120** can be constructed out of any suitable materials, including any suitable housing material, any suitable working fluid, and any suitable wick material. Heat pipes **120** can be shaped and sized to fit in any arrangement on printed wiring board **100**.

Heat pipes **120** are added to printed wiring board **100** during assembly of printed wiring board **100**. First ends **122** of heat pipes **120** are positioned under electronic components **110**, and second ends **124** of heat pipes **120** are mounted to posts **102**. Heat pipe **120** can be held on printed wiring board **100** by positioning it in this arrangement on printed wiring board **100**, or it can be further attached to printed wiring board **100** with any suitable manufacturing process, including bonding, welding, pressing, or soldering. In the embodiment shown in FIG. **3**, two heat pipes **120**A and **120**B are positioned on printed wiring board **100**. Flattened first end **122**A of heat pipe **120**A is positioned underneath electronic component **110**A. Second end **124**A of heat pipe **120**A is mounted to post **102**A. First end **122**B of heat pipe **120**B is positioned underneath electronic component **110**B. Second end **124**B of heat pipe **120**B is mounted to post **102**B. In alternate embodiments, the number and position of heat pipes **120** can vary. Further, the number of electronic components that are positioned near first ends **122** of heat pipes **120** can vary.

Placing first ends **122** of heat pipes **120** underneath electronic components **110** and mounting second ends **124** of heat pipes **120** to posts **102** is advantageous, as it more effectively transfer heat away from electronic components **110** to an ambient. Transferring heat through posts **102** is advantageous, as it provides a thermal pathway along which heat from printed wiring board **100** can be transferred to an ambient. This arrangement allows for more efficient heat transfer and more effective cooling of printed wiring board **100**. Having more effective cooling of printed wiring board **100** allows higher heat generating and more powerful electronic components **110** to be used on printed wiring board **100**. Being able to use more powerful electronic components **110** on printed wiring board **100** allows for greater flexibility in the design of printed wiring board **100** and allows more effective and reliable electronic components **110** to be used.

Mounting second ends **124** of heat pipes **120** to posts **102** is also advantageous, as it provides for more efficient energy transfer through posts **102**. Previously used arrangements that have a heat pipe ending near post **102** have a gap between an end of the heat pipe and post **102**. These arrangements have an inherent thermal resistance at the interface between the end of the heat pipe and post **102** where the heat has to transfer through the gap. Mounting second ends **124** of heat pipes **120** to posts **102** eliminates the thermal resistance and provides for more efficient heat transfer from second end **124** of heat pipe **120** to post **102**. Having more efficient heat transfer allows printed wiring board **100** to be used in higher temperature environments, as printed wiring board **100** can be more efficiently cooled.

The cost and time to assemble the overall printed wiring board assembly is also decreased, as no additional parts are needed to cool printed wiring board **100**. Some previously used applications used a heat sink to cool printed wiring board **100**, which adds weight and cost to the printed wiring board assembly. Other previously used applications would mount a heat pipe to a printed wiring board using thermal pads and other additional parts. The thermal pads and other parts are not needed when heat pipe **120** is attached directly to printed wiring board **100**. Overall, the cost and time to procure, store, manufacture, and assemble these additional parts are eliminated.

FIG. **4** is a cross-sectional view of the second embodiment of printed wiring board **100** taken along line **4-4** of FIG. **3**. Printed wiring board **100** includes post **102**A, fastener **104**A, washer **106**A, electronic component **110**A, and heat pipe **120**A. Heat pipe **120**A includes first end **122**A and second end **124**A.

Printed wiring board **100** is capable of holding electronic component **110**A and heat pipe **120**A. Heat pipe **120**A is positioned on a top side of printed wiring board **100**. First end **122**A of heat pipe **120**A is flattened during manufacturing so that first end **122**A of heat pipe **120**A can be placed between electronic component **110**A and printed wiring board **100**. Second end **124**A of heat pipe **120**A is also flattened during manufacturing and an aperture is manufactured into second end **124**A of heat pipe **120**A so that second end **124**A of heat pipe **120**A can be mounted to post **102**A on printed wiring board **100**. Heat pipe **120**A can be attached to printed wiring board **100** with any suitable means, including soldering or bonding.

Post **102**A is held on printed wiring board **100** by placing fastener **104**A the aperture in second end **124**A of heat pipe **120**A and into post **102**A. In effect, fastener **104**A also holds second end **124**A of heat pipe **120**A in place on printed wiring board **100**, as it passes through second end **124**A of heat pipe **120**A. When fully inserted, fastener **104**A runs through washer **106**A, second end **124**A of heat pipe **120**A, printed wiring board **100**, and into post **102**A.

With this arrangement, heat pipe **120**A will absorb heat from electronic component **110**A at first end **122**A. The heat will then be transferred through heat pipe **120**A with phase-change heat transfer. The heat can then be released from second end **124**A of heat pipe **120**A into post **102**A and transferred into an ambient.

This arrangement of heat pipe **120**A on printed wiring board **100** is advantageous, as it allows for more efficient and effective heat transfer. Heat can be transferred from electronic component **110**A through heat pipe **120**A to post **102**A, which will dispel the heat into an ambient. This arrangement more efficiently transfer heat through printed wiring board **100**, which allows for better cooling of printed wiring board **100**. Having better cooling of printed wiring board **100** allows higher heat generating and more powerful electronic components **110** to be used on printed wiring board **100**.

Mounting second end **124**A of heat pipe **120**A directly to post **102**A is also advantageous, as it eliminates the thermal resistance that previously existed between second end **124**A of heat pipe **120**A and post **102**A. Eliminating the thermal resistance provides for more efficient heat transfer through printed wiring board **100**. Having more efficient heat transfer allows printed wiring board **100** to be used in higher temperature environments on an aircraft. This allows for greater flexibility in the design of printed wiring board **100** and allows printed wiring board **100** to be placed in more locations on the aircraft.

While the invention has been described with reference to an exemplary embodiment(s), it will be understood by those skilled in the art that various changes may be made and equivalents may be substituted for elements thereof without departing from the scope of the invention. In addition, many modifications may be made to adapt a particular situation or material to the teachings of the invention without departing from the essential scope thereof. Therefore, it is intended that the invention not be limited to the particular embodiment(s) disclosed, but that the invention will include all embodiments falling within the scope of the appended claims.

The invention claimed is:

1. An apparatus comprising:

a printed wiring board;

a post that supports the printed wiring board; and

a heat pipe on the printed wiring board with a first end positioned near an electronic component attached to the printed wiring board and a second end positioned near the post.

2. The apparatus of claim **1**, wherein the first end of the heat pipe is positioned to absorb heat from the electronic component.

3. The apparatus of claim **1**, wherein the second end of the heat pipe is positioned to release heat into the post.

4. The apparatus of claim **1**, wherein the heat pipe is soldered, bonded, or pressed onto the printed wiring board.

5. The apparatus of claim **1**, wherein the first end of the heat pipe is positioned a first distance from the electronic component.

6. The apparatus of claim **5**, and further comprising:

a copper trace connecting the electronic component to the first end of the heat pipe.

7. The apparatus of claim **1**, wherein the second end of the heat pipe is positioned a second distance from the post.

8. The apparatus of claim 1, wherein the first end of the heat pipe is flattened to fit between the electronic component and the printed wiring board.

9. The apparatus of claim 1, wherein the second end of the heat pipe is flattened and has an aperture to be mounted to the post with a fastener running through the aperture.

10. The apparatus of claim 1, wherein the first end and the second end of the heat pipe are flattened by clamping them during manufacturing.

11. An apparatus for cooling an electronic component on a printed wiring board comprising:

a printed wiring board;

an electronic component attached to the printed wiring board;

a plurality of posts attached to the printed wiring board; and

a heat pipe attached to the printed wiring board with a first end near the electronic component and a second end near one of the plurality of posts.

12. The apparatus of claim 11, wherein the first end of the heat pipe is positioned to absorb heat from the electronic component, a phase-change heat transfer is used to transfer the heat through the heat pipe, and the second end of the heat pipe is positioned to release the heat into one of the plurality of posts.

13. The apparatus of claim 11, wherein a copper trace is positioned between the electronic component and the first end of the heat pipe.

14. The apparatus of claim 11, wherein a first end of the heat pipe is flattened and positioned underneath the electronic component.

15. The apparatus of claim 11, wherein a second end of the heat pipe is flattened and has an aperture through which the heat pipe is mounted to the post with a fastener.

16. A method for cooling an electronic component on a printed wiring board comprising:

absorbing heat into a first end of a heat pipe that is positioned on a printed wiring board from an electronic component on the printed wiring board;

transferring the heat through the heat pipe; and

releasing the heat at a second end of the heat pipe into a post supporting the printed wiring board.

17. The method of claim 16, wherein the heat pipe transfers heat with phase-change heat transfer.

18. The method of claim 16, and further comprising:

transferring heat from the electronic component through a copper trace on the printed wiring board to the first end of the heat pipe.

19. The method of claim 16, wherein the first end of the heat pipe is flattened and positioned between the electronic component and the printed wiring board.

20. The method of claim 16, wherein the second end of the heat pipe is flattened and has an aperture so that it can be mounted to the post with a fastener running through the aperture.

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